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FILMSTRIP TECHNIQUES FOR INDIVIDUALIZED INSTRUCTION

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FOREWORD

This study was initiated by the Behavioral Sciences Laboratory of the Aerospace Medical Research Laboratories, Aerospace Medical Division, Wright-Patterson Air Force Base, Ohio. The research was conducted in part by Graflex, Inc., Rochester, New York 14603, under Contract No. AF 33(657)-11339. Mr. William H. Trow, Project Engineer, was the principal investigator for Graflex, Inc. Dr. Edgar A. Smith of the Technical Training Branch, Training Research Division was the technical monitor. The research reported herein was begun in May 1963 and was completed in March 1964. The work was in support of Project 1710, "Training, Personnel and Psychological Stress Aspects of Bioastronautics," Task 171007, "Automated Training and Programed Instruction." Dr. Gordon A. Eckstrand was the Project Scientist, and Dr. Ross L. Morgan was the Task Scientist.

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This technical report has been reviewed and is approved.

WALTER F. GRETHER, PhD
Technical Director
Behavioral Sciences Laboratory

ABSTRACT

In the preparation of filmed programed instruction, several considerations are involved in the choice between slides and filmstrips. In this report, the considerations of revision, quantity, length, storage, recycling, aspect ratio, change time, random access and continuous repetition are briefly discussed. A comparison of costs of preparing a master of the filmed program and duplicate copies is made. As a guide to the preparation of filmstrips by staff photographers, some of the problems involved are discussed, namely, single-frame cameras, the preparation of flat copy, exposure and splicing. Other film formats with possible application in audio-visual programing are described.

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SECTION I.

FACTORS AFFECTING THE CHOICE OF FILMSTRIPS OVER SLIDES

There are several factors to be considered when selecting a film format as the visual medium in programmed instruction. The more important considerations entering into this choice are discussed below, followed by some considerations which may be important only in certain situations.

REVISION

Since the sequence of frames in a filmstrip is fixed, it is difficult to make deletions, additions or rearrangements. Therefore, any program which is subject to change, such as a programmed course undergoing validation or an industrial assembly training program, should be put on slides, which can be easily rearranged in the slide tray.

QUANTITY

The cost of duplicating filmstrips is considerably less than that for slides. This is not only because the film usage is halved, but also because neither the original nor the copies are cut and mounted. However, the cost of filmstrips is increased when they are made from slides. Thus, for small quantities, it may be less expensive to duplicate existing slides than to have a filmstrip made up professionally. Some sample costs are tabulated in Section II.

LENGTH

A filmstrip program can be of any length. Published filmstrips for classroom use are commonly between 25 and 60 frames in length, but one machine (the U. S. Industries' AutoTutor®) will handle up to 3000 frames. On the other hand, slide trays have spaces for a specific number of slides, ranging from 30 to 100. A program slightly exceeding in length the capacity of the slide tray will necessitate the use of a second tray.

STORAGE

Filmstrips are commonly stored in metal cans 1-1/2" in diameter by 1-1/2" high, holding up to around 200 frames. This 3-1/2 cubic inches of storage space can be compared to 35 cubic inches for 36 slides (almost 1 cu. in. per slide) for the Airequipt magazine, or to 220 cubic inches for 80 slides (2.75 cu. in. per slide) for the Kodak Carousel®. Thus slides may take up from around 10 to 150 times the storage space required for filmstrips.

RECYCLING

In order to repeat a program from the beginning, the filmstrip must be rewound. If it is not very long, this may be done by hand. Many filmstrip projectors are now provided with a freely rotating holder for the storage can out of which the film can be drawn from the inside, while automatically winding it on a power-driven spindle, ready for reuse. In the case of slides, however, the tray need only be started at the first slide position. For applications involving repetitive recycling, the

equipment may provide a stop against which the tray may be pushed to locate the first slide position.

ASPECT RATIO

The relationship of frame width to frame height is called aspect ratio. If a 35mm slide is shown vertically, as in the case of showing a tall object or a normal printed page, the aspect ratio is 2:3. Such a slide can be placed in a slide tray as easily as one with horizontal format, screen permitting. Filmstrips, however, are restricted to a horizontal format of aspect ratio 4:3. If a filmstrip requires the use of any vertical format material, this must be reduced to half size to fit the filmstrip frame. Also, when horizontal format slides are reduced to filmstrip format, the frames cannot be made to coincide exactly, due to the difference in aspect ratio. The layout and dimensions of single and double frames on 35mm film are shown in Fig. 1. The aspect ratios of vertical and horizontal formats mounted as 2" x 2" slides are illustrated in Fig. 2. Some filmstrips are produced with double frame horizontal format, necessitating horizontal film travel. This format is used to some extent by the U. S. Dept. of Agriculture and in Europe. Some filmstrip projectors accommodate both types, even though the double frame format is rarely used.

The following considerations may be involved in certain specialized situations:

CHANGE TIME

Most motor-driven slide changers take a little over one second to complete a change cycle, but none takes much less than that (the expensive Spindler and Sauppe twin drum machine being excepted). If near-instantaneous picture change is a requirement, then the filmstrip format should be selected for use in a solenoid-actuated projector.

RANDOM ACCESS

The fast-change feature of filmstrips also enters into the efficiency of random access systems. Filmstrips have been driven at 40 or more frames per second and stopped at a preselected frame, whereas one of the fastest known random access slide changers (Mast Development Co., using a 49-slide straight tray) takes up to 3 seconds to select and project a slide. The much larger capacity of a filmstrip reel compared to a slide tray is another important factor.

CONTINUOUS REPETITION

Although advertising display is the principal application for continuous repetition, it is also used in industrial assembly training. In the latter case, filmstrips are generally precluded because of the revision consideration, but under certain circumstances it may be desirable to use a spliced continuous-loop filmstrip for step-by-step instruction.

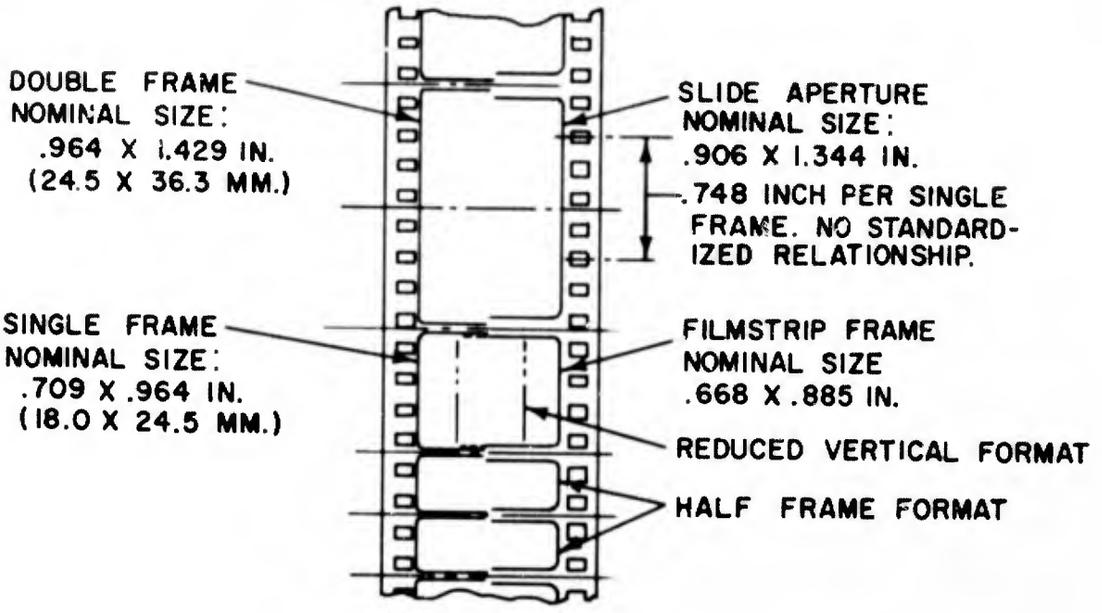


Figure 1. Single and Double Frame Formats on 35mm Film.

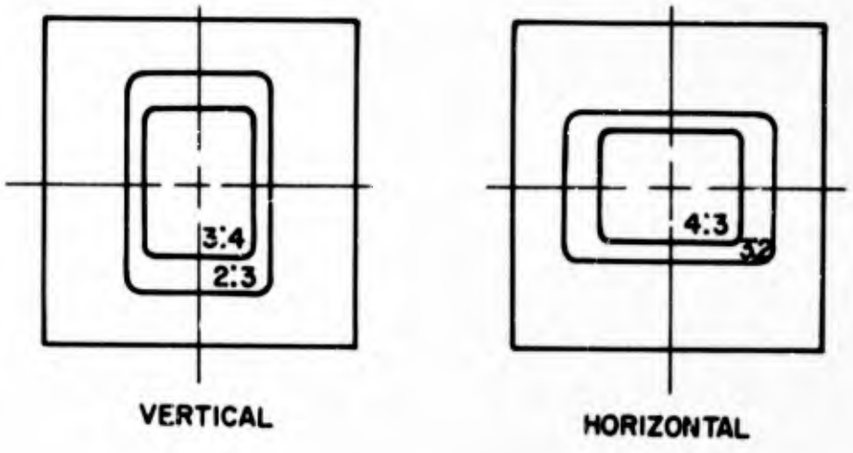


Figure 2. Aspect Ratios of 2" x 2" Mounted Single and Double Frame Slides

SECTION II

COST COMPARISON OF FILMSTRIPS AND SLIDES

Some sample prices for professional preparation and duplication of filmstrips were obtained from the Society for Visual Education, Inc. (SVE), Chicago, Illinois. Equivalent prices for slides were obtained from a professional photofinisher, Carhart Photo Inc., Rochester, New York. Of course, prices may vary widely from one region to another, with the degree of professional quality and with the processor's sales promotion effort. It is believed that the examples used here are typical for high quality work in a metropolitan area.

For preparation of a master filmstrip from color slides or from flat artwork, the SVE price is $2.00 per frame. Adding captions, masking, or color control costs an extra $3.00 or more per frame. Artwork done by SVE is available at $15.00 per hour. (The Keystone View Company, Meadville, Pennsylvania, in their effort to develop a market for the new Mast Teaching Machine, asks only 20¢ per frame for a master, which includes special perforating. Artwork is available at $5.00 per hour. Their duplication prices, however, are similar to SVE's.)

For comparison, Carhart's price for making a color slide from 8" x 10" artwork is $3.50. If one does one's own photography, the retail cost of color film and processing is around 15¢ per frame. However, the cost of one's time and equipment must also be considered. Table I gives the duplication prices from both sources, and also the amortized cost of the filmstrip master for various quantities.

TABLE I.

DUPLICATION COSTS OF FILMSTRIPS AND SLIDES (COLOR)

Number of copies	Filmstrip, per frame	$2.00 amort.	Total	Slide, each
1	-	200.0¢	200.0¢	30¢
5	5.3¢	40.0	45.3	30
10	5.3	20.0	25.3	30
100	4.3	2.0	6.3	25
1000	1.8	0.2	2.0	20

For black and white transparencies, the cost of film and processing is roughly one-half to one-third that of color, but this applies only if the original negative is available. If only flat artwork or a positive print or transparency (slide) is supplied, then the photofinisher's cost is doubled, since a new negative must be made for duplication. (If it is a positive transparency that is supplied, then the intermediate negative will be a negative print on paper.) Autopositive film is generally not used for audio-visual material due to the loss of definition.

A sampling of educational filmstrips from the SVE catalog shows that the price per frame averages around 15¢ for color and 6¢ for black and white. These prices, of course, cover the cost of program writing and editing, original artwork, typesetting, and marketing pro-rated over thousands of copies.

SECTION III

"DO-IT-YOURSELF" FILMSTRIPS

There are undoubtedly a considerable number of instances where a filmstrip could be prepared in-house without the aid of a professional photographer. But, in addition to the restrictions on the use of filmstrips discussed in Section II, one must make sure that every frame in the entire roll is exposed and focused correctly and that the frames are in the proper order. Otherwise, the replacement frames must be spliced in.

Certain types of programs allow this degree of consistency. For example, the best exposure for any black and white text or artwork can be ascertained and then used without change throughout the filming. Other examples, such as electronic circuit boards or control panels, could be photograhed in color under constant lighting conditions and from a fixed distance. On the other hand, if the materials to be photographed include more than one variety, such as color slides, prints, artwork or three-dimensional subjects, each setup must be well rehearsed for the best exposure so that the setup can be duplicated without failure. This may put excessive burden on the staff photographer, and professional filming from slides may be preferable.

As a guide to successful preparation of filmstrips by personnel in schools, hospitals, industry or military installations, a discussion of appropriate equipment and techniques follows, under the headings of cameras, preparation of copy, exposure and splicing.

CAMERAS

To allay any confusion, it should be noted at the outset that the format of filmstrips is half the size of the common 35mm still camera frame. For this reason, cameras having the filmstrip format are popularly called "half frame" cameras. However, to be consistent with the terminology of the American Standards Association, the term "single frame" will be used here, to distinguish it from the "double frame" format. Thus, the single frame 35mm filmstrip format is identical to normal 35mm moving picture format and analogous to 8 and 16mm moving picture formats. These moving picture formats, being as preponderant as they are, could not properly be called "half frame." Rather, it is the relatively recent 35mm still format that should be called "double frame." In this report, the term "half frame" will be reserved for a single frame divided in half lengthwise.

There are over a dozen single frame cameras currently available. Most of them are intended for candid use, having such features as zone focusing ("click stops" for portraits, groups or scenes) rather than a range finder. Many have one form or another of exposure control, ranging from matching the needle of a built-in light meter to a fully automatic exposure setting, which takes into account the film speed and shutter speed used. These are popular features but not particularly suited to the making of filmstrips. Far more important are the following requirements:

(1) The film must be sprocket-wound for uniform spacing of frames with a consistent relationship from roll to roll.

(2) The lens must focus "close up" for small area coverage.

(3) The viewfinder must allow accurate framing of the subject.

This third requirement comes about from the fact that a viewfinder, being usually about two inches

above the taking lens, "sees" a frame two inches higher than that photographed. Ordinarily, this makes little difference, but for distances less than three feet, an important edge of the picture may be cut off. Many viewfinders have parallax marks, that is, an off-set frame for the minimum focusing distance. This is not accurate enough for, say, photographing a printed page. For this reason, and also for reliably sharp focusing, a single lens reflex camera, or SLR, is recommended. An SLR camera has a pivoting reflex mirror between the lens and the film which reflects the image, exactly as it will be photographed, onto a ground glass which is viewed with a built-in magnifier. The mirror is quickly swung aside during the exposure of the film. The shutter in an SLR is generally of the "focal plane" type, which is immediately in front of the film and capable of high speeds.

For still greater accuracy in framing and focusing on flat artwork in a fixed setup, a small plate of ground glass with pencil marks at the center and corners may be held against the film guides before the film is loaded. By holding a small projector behind the ground glass, the film frame and pencil marks are projected onto the artwork where they can be viewed for precise adjustments. This technique may also be used if an SLR camera is not available.

There are, at the time of this report, very few single frame SLR cameras on the market. These are listed in Table II, which also gives the list price, the focal lengths, the minimum focusing distance and area covered at that distance, and any major distinguishing features.

TABLE II.

SINGLE FRAME, SINGLE LENS REFLEX CAMERAS

Model	List price	F. L.	Min. Foc.	Min. coverage
Olympus Pen F	$139.50	38mm	1'	4-1/4" x 6"
accessory	$ 99.95	100mm	5'	8-1/2" x 12"
accessory	$159.95	50-90mm zoom	5'	14" x 20" (50mm) 7-1/2" x 11" (90mm)
Alpa 6C (body only)	$379.00	50mm	7"	1-3/4" x 2-1/2" (est.)
Ceco Filmstrip (Camera Equipment Co., New York, N. Y.)	$850.00	90mm	1"	reel-loading

The minimum focusing distance may be decreased further by attaching to the front of the lens a suitable, good quality auxiliary lens. For extreme close-up work (macrophotography), suitable lenses with extension tubes should be used. However, this is a more specialized field requiring critical focusing and exposure compensation. Literature on the subject should be consulted.

PREPARATION OF FLAT COPY

A long-standing controversy is still unresolved concerning the preference of black-on-white versus white-on-black text for rear projection. Prolonged viewing of bright pages may be fatiguing, but visual acuity is sharper and smaller detail is clearly visible. On the other hand, with bright text on a black field, the letters, especially if small, will seem to scintillate due to the graininess of the screen. Thus larger printing is preferable. If black-on-white printed matter is being filmed, a more pleasing effect is obtained if the page is surrounded by a color background.

When photographing unmounted prints, magazine pages and the like, a print frame or cover glass is essential to hold the paper flat. It is better, when possible, to mount all flat copy on sheets of cardboard of a uniform size so that all copy materials may be positioned quickly by guides on the copy board, thus centering them in the field of view of the camera automatically. As an aid in preparing typed or illustrated frames, a printed form having the frame outlined on it may be made up or obtained commercially.

EXPOSURE

In the process of making the setup and test shots before the final run, several points should be kept in mind:

(1) The sequence of the program should be finalized with the approval of any concerned authority.

(2) The camera must be held so as to orient the horizontal filmstrip format properly. The top of the image must be the leading edge as the film is advanced. Therefore, as a rule of thumb, the film must always travel downward.

(3) The subject should nearly fill the field, but a margin of at least 1/20 of the frame width should be left to allow for possible misalignment in the projector film gate. When photographing objects, distracting detail in the background should be eliminated, either by paper or cloth shrouds or by making sure the background is far out of focus.

(4) A suitable film should be selected. For copying transparencies and when wide latitude is desired (detail visible in darker areas), a moderate-contrast color film, such as Ektachrome or Anscochrome, is recommended. For heightening the contrast of a low-contrast subject, or for eliminating detail in shadow areas, Kodachrome-II film may be used. If more than one copy is required, a negative color film such as Kodacolor should be used. Before having the film processed, make sure that the quality of the processor's work is reliable.

(5) For sufficient depth of field (nearest and farthest points of the subject in focus), a small aperture (f/8 to f/22) should be used. This will also give maximum sharpness in the corners. Since a small aperture causes the viewfinder to be too dim for accurate focusing, most new cameras have an "automatic diaphragm" which holds the aperture full open except during exposure.

(6) Since small apertures are recommended, the subject must be well illuminated. For three-dimensional subjects, the lighting should be placed so that shadows, as seen through the viewfinder, add to the sense of depth without obscuring important detail. Reflections from glossy surfaces should be minimized. (The distance from the subject that the photoflood or electronic flash should be placed, the f/no. and shutter speed to be used, and the choice of filter are all according to standard photographic technique and are beyond the scope of this report.)

(7) When copying transparencies, commercially available equipment for this purpose may be used, such as the Heiland Repronar ($350). Or, if one is so inclined, a simple light box may be constructed, having a ground glass on top, a hole in the side for indirect illumination by electronic flash, and painted flat white inside. If the transparency is somewhat under- or over-exposed, this may be compensated for by over- or under-exposing the filmstrip. More than one f/stop error in exposure on color film can be considered as unacceptable.

(8) Liberal use of test shots is well worth the effort. In making test shots, it is advisable to bracket the calculated exposure by one or two f/stops on either side, depending on the degree of uncertainty. If the material being photographed appears bluish or reddish, or if it is desirable to make a certain feature more prominent by enhancing its color, an appropriate filter may be used. However, it is important, whenever a different exposure, a variation in the lighting or a filter is used in shooting a filmstrip, that a script be written and scrupulously followed that lists every change from, and back to, the normal conditions.

SPLICING

There are two basic methods of splicing moving picture film which can also be used for filmstrips. One, a recent, quick and low-cost method developed for the home movie market, uses transparent pressure-sensitive mylar tape applied with the aid of a splicer. An example of this type of splicer is the Model 112, manufactured by Hudson Photographic Industries (HPI), Irvington-On-Hudson, New York. Both ends of the film are held in position firmly by the perforations, the ends are trimmed to match closely, and the tape is applied to both sides of the film. The sprocket hole spacing and alignment are maintained accurately by the splicer.

In the case of 8mm film splices, entrapped air bubbles and dust particles are highly magnified and are quite noticeable on the screen. With the lower magnification of 35mm film, the projected splice presents only a slightly cloudy but acceptable appearance, though the edge of the tape tends to collect dirt and become visible as a line across the middle of the frame. A wider variety of tape that covers a full frame on each side may soon be available. Such a splice does not curl the film, which would cause additional drag as it moves through the projector. Furthermore, this type of splice is reliable and durable. In laboratory tests made at Graflex, Inc., a splice survived over 1600 passes through a solenoid-actuated projector, outlasting the film perforations.

The second method of splicing has been in use since the inception of the moving picture. After the emulsion layer has been scraped off a narrow band across one end of the film, a lap joint is made, using a clear cement. The perforations are held in alignment as before. There are several 35mm splicers of this type on the market, among them one manufactured by Griswold Machine Works, Port Jefferson, New York. There are a few minor disadvantages associated with this method. For example, a little practice is usually needed to make a good splice, excess cement is sometimes troublesome, and the process takes somewhat longer than with tape. Some cements cause curling of the film when exposed to the heat of the projector. Also, the overlap of the joint is thicker and may not pass through the film gate of many projectors. But most importantly, this type of splice necessitates the loss of a frame, because of the overlap, and so can only be used when deleting one or more frames or when attaching leaders or making loops when there is excess film at the ends of the strip.

STANDARD SPECIFICATIONS FOR 35mm FILMSTRIPS

The filmstrip industry generally adheres to the following standard practice regarding the length of the leader and trailer and the information to be contained thereon. Although there is no requirement that non-commercial filmstrips follow this practice, it may be of interest to those who wish to work according to conventional procedures.

1. The trimming of the leading edge of the film shall be a straight cut located between sprocket openings and at 90° ± 3° with the edge of the film.

2. The first three frames of the film shall have the word START in large block lettering appearing on each frame as follows:

   2a. If color film is used, the background color shall be green with white lettering.

   2b. If black and white film is used, the background is to be black with white lettering.

   2c. A white dot not less than 1/8" in diameter shall appear in the upper left hand corner.

3. The distance from the cut leading edge of the film to the top of the "focus" frame is to be no less than 9 frames or approximately 6-3/4 inches. Information identifying the filmstrip may appear across the 4th through 7th frames, preferably parallel to the film edge.

4. The focus frame is located as specified by standard 3 and should contain a simple design pattern so that the projected picture can be accurately located and sharply focused on the screen.

5. The title frame (or first information frame) of the film shall be no less than the 11th frame from the leading edge of the film.

6. If a sound medium accompanies the film, a notation shall appear on the focus frame which will indicate to the operator the proper frame on which the recording is to be started.

7. The distance from the bottom of the "end" frame to the cut end of the film shall have a minimum length equal to the circumference of the container in which it will be stored.

8. The last two frames before the cut end of the film shall have the word END in large block lettering appearing on each frame as follows:

   8a. If color film is used, the background color shall be red with white lettering.

8b. If black and white film is used, the background is to be black with white lettering.

9. The frame size shall be .885 ± .003 wide by .668 ± .003 high, the corner radius shall be .016R. and the left edge shall be .442 ± .003 from the centerline of the film.

SECTION IV

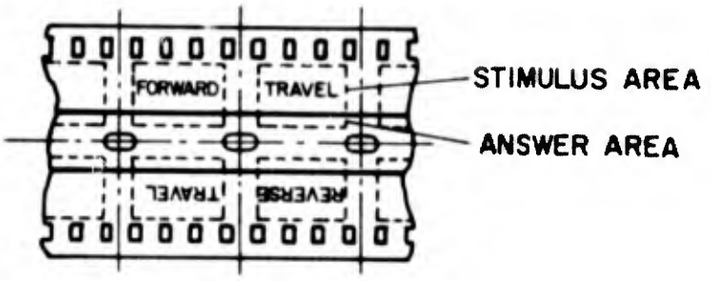
OTHER FORMATS

From time to time, an audio-visual or data-storage equipment manufacturer initiates a non-standard film format in order to make a major design advance. This usually involves the development of new reproduction and processing equipment, or at least the modification of existing equipment. However, the standard widths and sprocket hole patterns for 8, 16 and 35mm film are generally adhered to. The standard formats for 35mm frames and the slide mounting thereof have alrady been illustrated in Figures 1 and 2.

The Mast Teaching Machine format, referred to earlier, is pictured in Figure 3A, which shows the special center perforations and the heavy line separating the answer area from the stimulus area of the frame. The cartridge in which these programs are stored may be turned over in its position on the projector, so that a showing of a continuation of the program rewinds the filmstrip to the starting point, as in an RCA-type tape recorder cartridge. In addition, the Mast cartridge is double, containing a second filmstrip. In this way, up to 800 frames may be contained in a single cartridge using the equivalent of two 200 single-frame filmstrips.

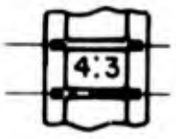
Figures 3B and 3C show the standard single-frame 16mm and 8mm moving picture format which require vertical film transport. Both of these have been used, at least experimentally, in still projection for programmed instruction. The half-frame 8mm is used in the TMI-Grolier Multi/Max teaching machine. Figures 3D and 3E show some non-standard double-frame variations on 16mm and 8mm film requiring horizontal film transport for horizontal format. If singly perforated 16mm sound film is used, the frame may be extended nearer one edge, allowing the single-frame 4:3 aspect ratio. For comparison, the sprocketless "sub-miniature" cameras produce the format shown on the right in Figure 3D. It may be noted that the aspect ratio of this frame is $\sqrt{2}$:1 (midway between 3:2 and 4:3) which enlarges to 5" x 7" and other standard print sizes.

A rather different film format which has come into recent use in microfilm data-storage applications may also find a place in programmed instruction. This is the microfiche, a rectangular sheet of film carrying rows and columns of micro-images. The National Microfilm Association has recently proposed four standard sizes which are illustrated in Figure 4. Viewing or projection of a microfiche requires a special carriage with x and y traverse. The potentialities of the microfiche in programmed learning, with regard for its suitability for branched programs, remains largely unexplored.

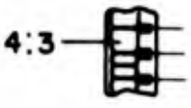


A. MAST TEACHING MACHINE FORMAT
(SPECIALLY PERFORATED 35MM.)

VERTICAL TRANSPORT

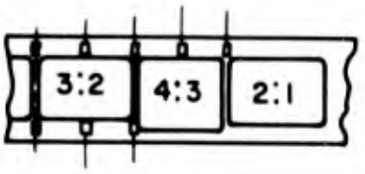


B. SINGLE FRAME 16MM.
(SILENT MOVIE FORMAT)

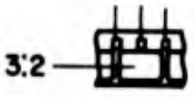


C. SINGLE FRAME 8MM.
(HOME MOVIE FORMAT)
HALF FRAME USED IN
TMI MULTI/MAX.

HORIZONTAL TRANSPORT



D. DOUBLE FRAME 16MM (L.)
SINGLE PERFORATION SOUND
FILM (C.) SUB-MINATURE
FORMAT (10 X 14 MM., R.)



E. DOUBLE FRAME 8MM.

Figure 3. Other Filmstrip Formats (Full Scale).

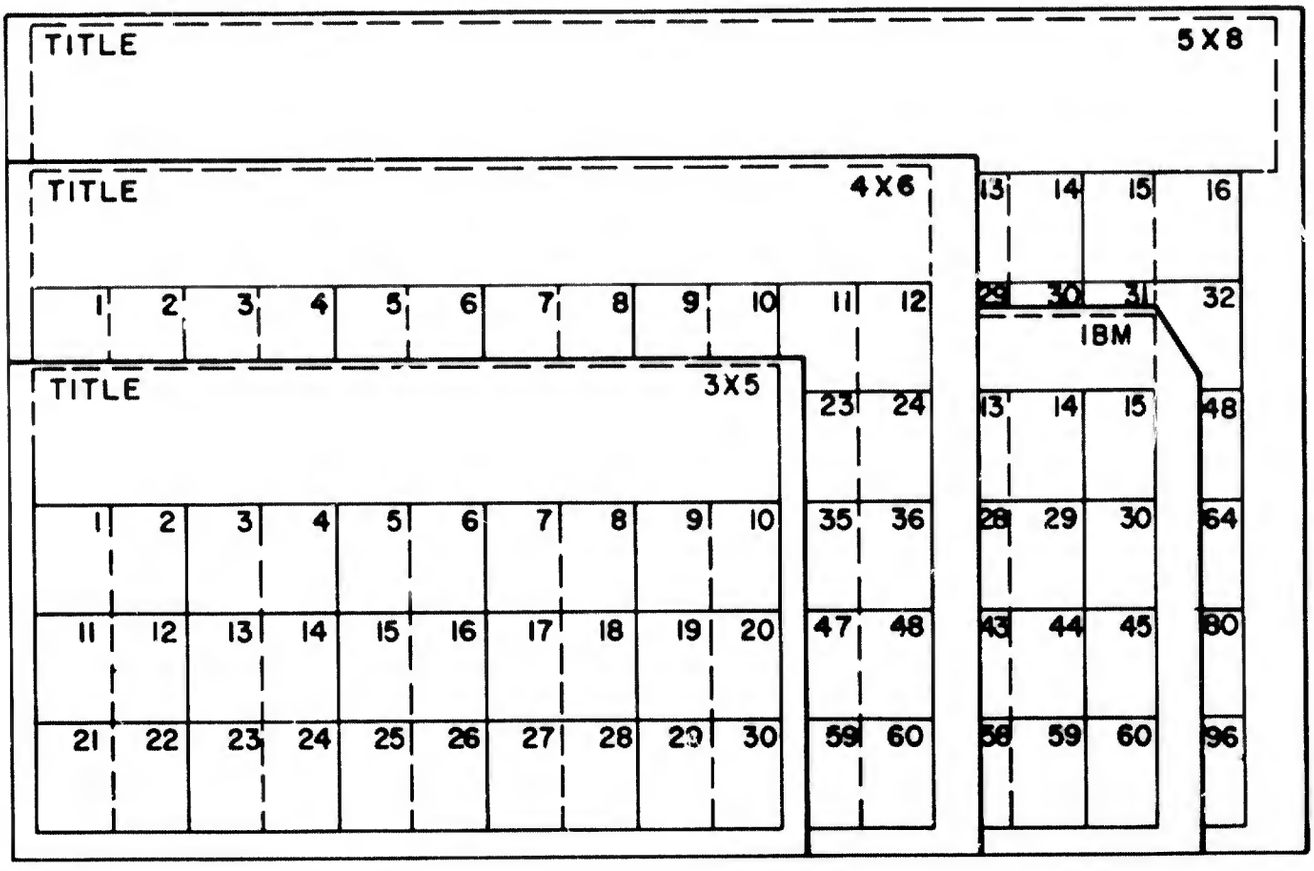


Figure 4. Proposed Microfiche Standard (1963) Four Sizes, Showing Single and Double Frame Placement (Full Scale).

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